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EXPERIMENTAL AQUATIC WEED CONTROL WITH ENDOTHAL-SILVEX, DIQUAT AND SIMAZINE

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EXPERIMENTAL AQUATIC WEED CONTROL
with
ENDOTHAL-SILVEX, DIQUAT AND SIMAZINE

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TABLE OF CONTENTS

SUMMARY

There was little difference in the effectiveness of granular and liquid formulations of Endothal-Silvex in controlling submergent vegetation. Good control was achieved with this herbicide on quarter-acre and half-acre plots at 3 ppm active, while 2 ppm provided certain control only on the latter. Applications at 1 ppm were ineffective. Seasonal control was achieved at effective rates.

Diquat provided rapid and spectacular results in controlling submergent species at a rate of two gallons per acre, but in several cases control was of a temporary nature. One gallon per acre provided temporary control of water milfoil. With Diquat, control usually extended well beyond the margins of the areas treated.

Simazine controlled filamentous algae and most submergent vascular plants at rates of 1 ppm and 2 ppm active in wholly treated ponds except where flow-throughs were significant. *Chara* spp. were not well controlled at 1 ppm. Drawdown treatments at 15, 20 and 30 pounds active Simazine per acre provided fair to good control of roundstem bulrush

and 20 pounds active controlled Chara.

No harm to fish was observed in areas treated with Endothal-Silvex and Diquat. Use of Simazine produced oxygen depletions in several ponds but no direct toxic effects to fish or invertebrate life were noted. This same algicide-herbicide temporarily reduced phytoplankton production. Leaves of willow trees growing adjacent to the pond margins were affected and three willow trees were severely damaged.

LIST OF FIGURES

LIST OF TABLES

EXPERIMENTAL AQUATIC WEED CONTROL
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1. INTRODUCTION

In Ontario, the majority of problems associated with excessive growths of aquatic vegetation are confined to the St. Lawrence lowlands area, situated between the Precambrian Shield and the Great Lakes System. Lakes and rivers in this fertile, well-populated agricultural and industrial area appear to be demonstrating an accelerated rate of eutrophication, relative to the numerous, generally poorly-buffered waters present throughout the granitic rock country that comprises the Precambrian Region. Copious production of phytoplankton and/or many species of submergent vegetation is notable in such bodies of water as Lake St. Clair, Rondeau Bay and Long Point Bay on the north shore of Lake Erie, Frenchman's Bay and the Bay of Quinte on the north shore of Lake Ontario, backwater areas of the St. Lawrence River, the Kawartha Lakes and Trent Canal system, the Rideau River, expanded portions of the Ottawa River and the shallow portion of Lake Simcoe known

as Cook Bay. Numerous man-made reservoirs and farm ponds in Southern Ontario support seasonal growths of filamentous algae and submergent vascular vegetation. Problems faced in these waters are similar to those outlined for many states and other provinces by numerous authors, including - reductions in property values and aesthetic qualities; interference with swimming, boating and other water-oriented recreational activities; as well as accumulations of odoriferous plant material along shoreline properties.

Ryder (6), in a report relating water chemistry to fish production, points out that lakes 'situated in formerly submerged regions are potentially more productive than lakes in the exposed Precambrian Shield Region'. It is noteworthy that aquatic vegetation is extremely abundant in shallower portions of northern lakes such as Lake of the Woods, situated on extinct Lake Agassiz, and in Lake Nipissing, overlying post-Algonquin Lake Stanley. Undoubtedly, both edaphic and morphometric characteristics are responsible for the generous phyto-production in these two lakes. Little concern has been expressed about growths of aquatic vegetation in these waters because they are highly valued for sport fishing and because other forms of

water recreation can still be enjoyed in certain portions of these same lakes, or in other lakes nearby.

This report outlines the results of herbicide evaluation tests undertaken during the summer of 1965 as part of a continuing program to demonstrate the suitability of herbicides for use in the aforementioned waters. Chemicals utilized in the tests were Diquat (1,1-diethylene-2,3-dipyridilium dibromide), Endothal-Silvex [dipotassium salt (3,6-endoxo hexahydrophthalic acid] + potassium salt [2-(2,4,5-trichlorophenoxy) propionic acid], and Simazine [2-chloro-4,6-bis (ethylamino)-s-triazine].

2. DETAILS PERTAINING TO TESTS AND PROCEDURES USED

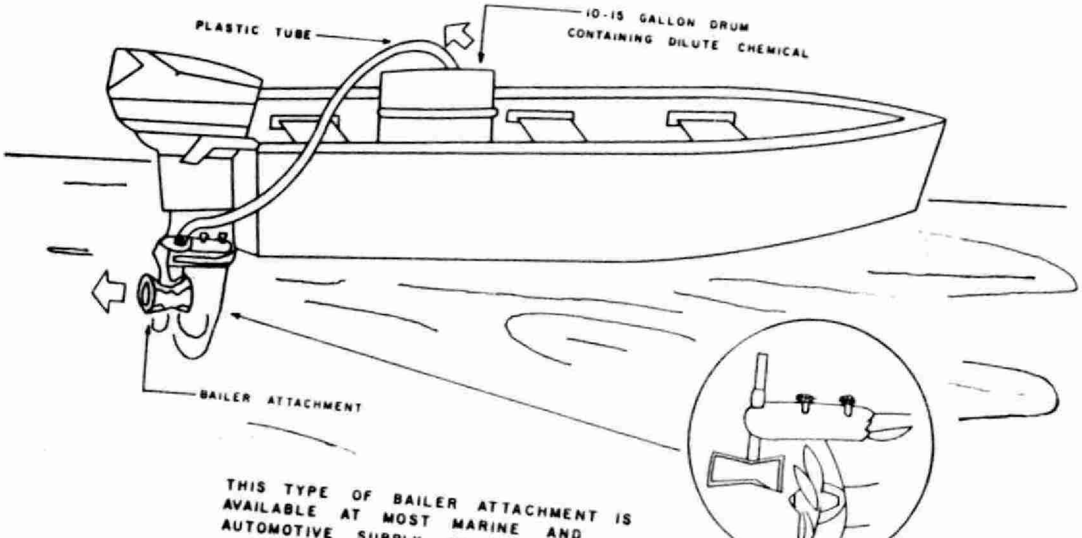
Applications of Endothal-Silvex were designed to evaluate plot size, concentration used, type of formulation (liquid or granular), and early season versus late season applications. While the use of Diquat for controlling algae and submergent vegetation has been quite well documented by Blackburn (1), Lopinot (3), Riemer (5) and Whitley (9), insufficient information was available to substantiate its effectiveness for partial treatments in large lakes. Also, the validity of treating on a gallonage-per-aere basis required further evaluation. The herbicidal

and algicidal value of Simazine appeared to be beyond doubt on the basis of work by Johnson (2), Snow (7), Walker (8) and Pierce et al. (4); however, it was felt that corroborative data were required on the permanency of control, effectiveness against certain species, and the magnitude of effects on invertebrate and phytoplankton populations.

Endothal-Silvex was tested in Rice Lake (21,862 acres and Sturgeon Lake (10,616 acres) in the Kawartha Lakes Region. Diquat was applied to plots in Rice Lake, Rondeau Bay of Lake Erie (6,000 acres) and in a relatively small lake north-east of Metropolitan Toronto. Experiments with Simazine were conducted in twenty farm ponds throughout an agricultural area immediately north of Metropolitan Toronto and in one pond located at a fish hatchery operated by the Ontario Department of Lands and Forests.

With the exception of several drawdown plots, all of the chemicals were applied from a motor boat. Liquid formulations, as well as the wettable powder form of Simazine, were injected into the water by means of a simple type of boat bailer, employing suction to draw the liquid chemical or wettable powder-water slurry from a drum in the boat. Granular Endothal-Silvex was applied by means of a motorized rotary seeder mounted on the front of a boat and manipulated by remote control. Applications of Simazine following drawdowns in two situations were accomplished by means of a portable spray

SIMPLE BAILER ATTACHMENT FOR APPLYING AQUATIC HERBICIDES



boom, connected by hose to a gasoline-powered pump and operating at a pressure of 40 p.s.i.

Application rates were expressed in terms of gallons product per acre (Diquat), parts per million by weight (Endothal-Silvex and Simazine), or pounds active per acre (Simazine drawdown trials).

Water samples were collected for chemical analyses, including pH, hardness, total alkalinity and total dissolved solids. Observations were made following treatments to evaluate herbicidal effects and to determine whether fish and other aquatic life were affected by the applications. In the farm pond studies with Simazine, samples of bottom muds and pond water were taken before and after treatment to determine whether or not there were apparent effects on invertebrate life and phytoplankton populations. For the latter, samples were concentrated prior to counting in a Sedgwick-Rafter cell, and an areal standard method of enumeration was used.

3. ENDOTHAL-SILVEX TESTS

Endothal-Silvex was tested in two lakes having mean total alkalinities of 78 ppm and 93 ppm, respectively. Average pH values derived from a number of determinations

were 8.2 and 8.4. Total dissolved solids concentrations were 151 ppm and 173 ppm.

As mentioned previously, nine plots were treated with this herbicide to demonstrate possible relationships among interrelated factors including plot size, concentration used, type of formulation (liquid or granular) and time of treatment. Species present on all plots but one included Canada waterweed, *Anacharis canadensis*, water milfoil, *Myriophyllum exalbescens*, coontail, *Ceratophyllum demersum*, tapegrass, *Vallisneria americana*, and one or more species of pondweed, *Potamogeton* spp. *Chara* spp. were present in some cases. Table 1 illustrates the results that were achieved. Neither formulation was effective on quarter-acre plots at 1 ppm active and control at 2 ppm active on plots of this size was incomplete and usually temporary. A quarter-acre treatment of liquid Endothal-Silvex at 3 ppm provided good control (85-90%), although scattered strands of viable *Anacharis* and *Chara* remained at the bottom during the balance of the season. Both 2 ppm and 3 ppm active (liquid and granular) on half-acre plots provided seasonal control, but again, some slight recovery of *Anacharis*, *Vallisneria* and *Chara* was noted at the bottom in each case. *Chara* showed more resistance than any of the other plants

Table 1. Results of applications of Endothal-Silvex for controlling submergent aquatic vegetation.

No. of Plots	Size of Plots	Date Applied	Vegetation Present	Rate Used	Results Achieved
2	¼-acre	June 15 June 29	Anacharis, Myriophyllum Ceratophyllum, Potamogeton spp. Vallisneria	1 ppm Granular and Liquid	No control
2	¼-acre	June 16	Anacharis, Myriophyllum Ceratophyllum, P. zosteriformis Vallisneria	2 ppm Granular and Liquid	Retardation of growth only
2	¼-acre	July 27	Anacharis, Myriophyllum P. Richardsonii, Vallisneria	2 ppm Granular and Liquid	Retardation of growth only
1	¼-acre	July 27	Anacharis, Myriophyllum Potamogeton spp. Vallisneria	2 ppm Liquid	Prolonged 80% control
1	¼-acre	July 27	Anacharis, Myriophyllum P. Richardsonii, Vallisneria Chara	3 ppm	Good - prolonged (Bottom recovery)
1	½-acre	June 16	Anacharis, Myriophyllum Ceratophyllum P. zosteriformis	1 ppm Liquid	No control
1	½-acre	June 25	Myriophyllum Ceratophyllum	2 ppm	Good - prolonged (bottom recovery)

Continued

Table 1. Results of applications of Endothal-Silvex for controlling submergent aquatic vegetation.

No. of Plots	Size of Plots	Date Applied	Vegetation Present	Rate Used	Results Achieved
2	½-acre	July 27	Anacharis, Myriophyllum P. Richardsonii Vallisneria, Chara	2 ppm Granular and Liquid	Good - prolonged (bottom recovery)
2	½-acre	June 25	Anacharis, Myriophyllum P. Richardsonii Vallisneria, Chara	3 ppm Granular and Liquid	Good - prolonged, except for Chara

where it was present and demonstrated healthy advancement in one situation.

Unlike Diquat, as will be outlined later, Endothal-Silvex did not provide any significant reduction of vegetation beyond the margins of the treatment plots. On the other hand, permanency of control was generally superior where Endothal-Silvex was used at effective rates.

4. DIQUAT TESTS

Diquat was tested in three hard-water lakes (total hardness 90-190 ppm). Methyl orange alkalinities ranged from 59 to 83 ppm and pH values varied between 7.5 and 9.5. Total dissolved solid content varied rather widely from 135 ppm to 286 ppm.

Table 2 indicates the plants that were present on the seven plots treated and the nature and permanency of control achieved. The results of shoreline and open-lake tests with Diquat at a rate of two gallons commercial product per acre were quite spectacular, providing drastic reduction to total elimination of aquatic vegetation in all cases in three to four days. Insufficient tests were completed at one gallon per acre to indicate the suitability of this rate, although water milfoil (*Myriophyllum exalbescens*) was temporarily eliminated in one situation.

Table 2. Results of applications of Diquat for controlling submergent aquatic vegetation and algae.

Plot size	Date applied	Vegetation present	Average depth	Rate used	Results achieved (submergents)
3/4-acre	June 7	Anacharis, Myriophyllum Potamogeton spp., Hydrodictyon	3'	2 gals. per acre	Temporary elimination
3/4-acre	June 8	Anacharis, Myriophyllum	3'	2 gals. per acre	Prolonged elimination
3/5-acre	June 17	Myriophyllum, Ceratophyllum Hydrodictyon	3'	2 gals. per acre	Prolonged elimination
1-acre	June 22	Myriophyllum	6'	2 gals. per acre	Temporary elimination
1-acre	June 23	Myriophyllum	6'	1 gal. per acre	Temporary elimination
1/2-acre	July 14	Anacharis, Myriophyllum Ceratophyllum, Vallisneria	2.5'	1 gal. per acre	Poor - vegetation only browned
1200'x30'	July 8	Myriophyllum, P. amplifolius	5'	2 gals. per acre	Temporary reduction

At two gallons per acre, the effectiveness of the chemical was clearly demonstrated against Canada waterweed, *Anacharis canadensis*, water milfoil, *Myriophyllum exalbescens*, coontail, *Ceratophyllum demersum*, and a number of pondweeds (*Potamogeton crispus*, *P. pectinatus*, *P. filiformis*, *P. zosteriformis*, and *P. Richardsonii*). Bassweed, *Potamogeton amplifolius*, appeared to be somewhat more resistant to Diquat than the other pondweeds, on the basis of one application. The net-like alga *Hydrodictyon* and the filamentous alga *Spirogyra* were eliminated temporarily.

Virtual elimination or drastic reduction of vegetation in the untreated areas adjacent to the plots was noted, most pronounced in the direction of the prevailing current in each case. In three situations, this "bonus" control occurred over areas as large as the plots themselves (i.e. 3/4 - 1 acre) and was even substantial at the one-gallon-per acre rate when used against water milfoil.

The duration of control achieved with Diquat suggested a "chemical mowing" effect in most cases. Bottom growths of *Potamogeton Robbinsii* and *Vallisneria americana* were evident on one plot after four weeks and the alga *Hydrodictyon* had returned, also. Late in the summer on this plot,

Figure 2 Waterfront area in Rice Lake prior to use of Diquat at 2 gallons per acre

Figure 3 Same area after treatment with Diquat

the vegetation had reached half-way to the surface. Good residual control was achieved on two other plots, where short, spotty growth was of little consequence nearly three months after treatment. One noteworthy development was the dominant appearance of Vallisneria in three plots where it had not been evident prior to treatment.

A treatment was undertaken to provide a channel for boat traffic in an area 1200 feet long by 30 feet wide. Water milfoil was the cominant plant, reaching thickly to the surface along the entire route. This plant was severely "burned off" following treatment, revealing the presence of Potamogeton amplifolius, P. crispus and Vallisneria americana, which appeared to be relatively unaffected by the Diquat. Six weeks after treatment, milfoil again dominated and was growing almost to the surface along most of the channel.

In two one-acre plots where Myriophyllum exalbescens was the exclusive plant species, total elimination appeared to be achieved following treatment at both one- and two-gallon-per-acre rates. However, the milfoil densely revegetated both plots within six weeks.

The algae Hydrodicyton and Spirogyra were present in three situations and were successfully controlled for a period of four to six weeks.

5. TESTS WITH SIMAZINE IN FARM PONDS

Artificial warm-water and cool-water ponds were included in the study, ranging in size from .1 to 2 acres, except for one larger pond treated on a drawdown basis. The cool-water ponds are spring- or stream-fed and have a mean alkalinity of nearly 200. In the warm-water ponds the mean alkalinity is approximately 100. Values for pH for the twenty-one ponds range from 7.7 to 9.2.

Simazine (wettable powder) was applied during the spring for control of filamentous algae at rates of 1, 1.5 and 2 ppm active (weight), based on the total volume of water in each pond. Also, several species of submergent vascular vegetation were present in some ponds tested at 1 ppm and 2 ppm. The ponds selected had a history of problems associated with nuisance growths of vegetation and most were supporting algae or submergent aquatics in early stages of development at the time of treatment. Lowering of the level of one large pond (approximately 8 acres) exposed the bottom around its periphery and pre-emergence applications of Simazine were attempted for control of round-stem bulrush, *Scirpus validus*, and cattails, *Typha latifolia*. The herbicide was applied to the wet mud early

Table 3. Results of using Simazine in 20 farm ponds and one fish hatchery pond.

Species	Rate	No. of Ponds or Plots	NATURE OF CONTROL Excellent	Good	Fair	Poor
Chara vulgaris	2 ppm	3	2	-	-	1*
Chara vulgaris	1 ppm	8	2	2	2	2
Spirogyra spp.	1 ppm	7	6	-	-	1*
Cladophora sp.	1-1.5 ppm	3	2	-	1	-
Mougeotia	1.5-2 ppm	3	2	1	-	-
Potamogeton pectinatus	2 ppm	1	1	-	-	-
Potamogeton pectinatus	1 ppm	5	4	-	1	-
Potamogeton filiformis	1 ppm	3	1	-	1	1*
Potamogeton zosteriformis	2 ppm	1	1	-	-	-
Potamogeton crispus	1 ppm	2	1	-	-	1*
Vallisneria americana	1 ppm	4	2	1	-	1*
Anacharis canadensis	1 ppm	2	1	-	-	1
Myriophyllum exalbescens	1 ppm	1	-	-	-	1*
DRAWDOWN						
Chara sp.	20/lbs/A	1	1	-	-	-
Scirpus validus	15 lbs/A	2	-	-	2	-
Scirpus validus	20 lbs/A	2	-	2	-	-
Scirpus validus	30 lbs/A	2	1	1	-	-
Typha latifolia	20 lbs/A	2	-	-	-	2
Typha latifolia	30 lbs/A	1	1	-	-	-

*Ponds with substantial flow-through

in May. Duplicate rates of 15, 20 and 30 pounds active ingredient were used on half-acre plots in these tests. One small pond was lowered and similarly treated for control of *Chara* sp. at a rate of 20 pounds active per acre.

Results of all experiments with Simazine are summarized in Table 3. The herbicide was generally effective in controlling *Spirogyra* spp., *Cladophora* sp. and *Mougeotia* sp., at a rate of 1 ppm active ingredient. The various species of *Potamogeton* appeared to be quite sensitive to the chemical at the same rate, as did *Vallisneria*. *Chara* spp. and *Anacharis canadensis* were more resistant. Substantial regrowth of *Chara* materialized in three ponds and *Anacharis* became re-established following a severe reversal in one pond, though it did not reach the surface as it had in previous seasons.

A drawdown application of Simazine at 20 pounds active per acre in early spring proved to be effective in controlling *Chara* for the balance of the season. This same rate, similarly applied prior to emergence, provided good reduction of round-stem bulrush, *Scirpus validus*. Total elimination was achieved in one plot where *Scirpus* was treated at 30 pounds active per acre. Also, this higher rate

controlled cattails, *Typha latifolia*, while the 20-pound rate was ineffective.

The presence of inflow and outflow in wholly treated ponds was obviously an important factor in influencing the effectiveness of the treatments. Three of the ponds where results were poor were fed by streams which provided substantial dilution during a three-to four-day period following the applications. Noticeable reduction of vegetation usually did not become evident following treatment for a minimum period of eight to ten days and substantial dilution during this period led to lack of control. The effect of dilution was best demonstrated at a hatchery pond where the herbicide became diluted to half the applied concentration after four days, when water had to be pumped into the pond to prevent maskinonge fry from being affected by declining dissolved oxygen levels. Control of *Spirogyra*, which had been eliminated in six other ponds, was minimal in this case.

6. DIRECT AND INDIRECT EFFECTS ON FISH

Results of laboratory bioassay tests on fish for the three herbicides used in this study are provided in Table 4. All tests were performed on lake emerald shiners (*Notropis atherinoides*) at 21°C in Toronto tap water, having a total

hardness of 135 ppm as $CaCO_3$. It is obvious from this table that satisfactory margins of safety to fish exist for all three chemicals, although the disodium salt of Endothal-Silvex was tested rather than the dipotassium salt which was used in the herbicidal trials.

Table 4. Laboratory fish toxicity data for Endothal-Silvex, Diquat and Simazine

	TLm, mg. active per litre			
	4 hours	24 hours	48 hours	96 hours
Endothal-Silvex*	>1000	780	612	510
Diquat	> 180	180	86.2	25.8
Simazine (50% W)	Non-toxic to 18 ppm active			

*disodium rather than dipotassium salt

As expected, no direct harmful effects to fish were observed in connection with any of the treatments in the field. Bluegills were observed guarding their nests on one plot where Diquat was applied and were still present 28 hours after the application had terminated. Indirect effects to trout and bass resulted following Simazine applications in one cold-water and one warm-water pond. In both cases, the concentrations of dissolved oxygen were reduced to critical levels by decomposition of plant material

and drastic reductions in populations of phytoplankton, the latter normally ensuring satisfactory oxygen tensions during photosynthetic production. In a cold-water pond, serious mortality of rainbow and speckled trout developed ten days after treatment when the dissolved oxygen level dropped to 0.0 ppm near the bottom. Cyprinids managed to survive by remaining near the surface where the dissolved oxygen level remained at 2.2 ppm. Mortality of largemouth bass commenced in a warm-water pond fifteen days after treatment but did not become serious because water was pumped forcefully into the pond to increase the dissolved oxygen concentration. Similar action was taken to protect young maskinonge in the hatchery pond that was treated. Altogether, critical dissolved oxygen levels developed in six of the 20 wholly-treated ponds but three of these did not contain game fish. The reduced oxygen levels persisted for several weeks where no corrective action was taken.

7. EFFECTS ON BOTTOM FAUNA AND PHYTOPLANKTON

No gross reduction in numbers of bottom-dwelling organisms was indicated by quantitative dredge samples taken before and after treatment. Table 5 summarizes the results of sampling in eight ponds for this purpose. Caddisfly

Table 5. Average number of invertebrates per square foot in study of eight ponds treated with Simazine.

TAXA PRESENT	PRE-TREATMENT LEVEL	2-6 WEEKS AFTER TREATMENT	10-14 WEEKS AFTER TREATMENT
Aquatic worms	13.60	47.90	42.50
Midges	13.90	35.40	23.40
Biting midges	.63	1.60	.85
Snails	2.80	3.90	3.40
Leeches	.70	.30	1.00
Amphipods	.18	-	.25
Caddisflies	1.70	-	-
Dragonflies	.25	.75	-
Beetles	.25	.06	.54
Water bugs	.06	-	.38
Water mites	.06	.13	.60
Clams	.11	1.30	.13
Fairy shrimp	.13	-	-
TOTAL	34.37/sq.ft.	91.34/sq.ft.	73.05/sq.ft.

larvae were reduced in numbers, probably as a response to the reduction in vegetation, since species in this group are closely associated with and utilize plant material in constructing their protective cases. This lack of demonstrable effects was verified by qualitative sampling with a Needham scraper along the edges of all ponds treated. These observations are in agreement with those of Walker (8) who found that bottom fauna populations were not seriously affected in Simazine-treated plots.

Sixteen ponds were studied to determine the effects of Simazine on phytoplankton. Flagellated types of algae such as _Chlamydomonas_, _Dinobryon_, _Peridinium_, _Euglena_, _Trachelomonas_ and _Ceratium_ dominated in seven ponds prior to treatment and were co-dominant with non-motile green algae, blue-green algae and diatoms in five others. The latter three groups, either singly or in combination, dominated in the remaining four ponds. Most frequently observed non-motile green algae in the ponds were _Schroederia_, _Chlorella_, _Ankistrodesmus_ and _Closterium_. _Synedra_ and _Navicula_ were the two most prominent diatoms. The diatom _Synedra_ was observed in pre-treatment samples from every pond involved in the study. Blue-green algae were of lesser importance than the other groups. Genera present in eight

ponds prior to treatments included Oscillatoria, Anabaena, Anacystis and Gomphosphaeria.

Enumerations of phytoplankton in samples collected from the 16 ponds before and two weeks after the applications of Simazine provided conclusive evidence of reduction or curtailment of phytoplankton production. In 10 of the ponds, numbers of phytoplankton were reduced to insignificant levels after two weeks. Subsequently, levels remained low in several ponds and increased in others during a 70-day period, demonstrating no consistent pattern. However, ponds that showed increases above pre-treatment levels during this same period were stream-fed ponds with significant flows through them.

In general, the flagellates Dinobryon, Chlamydomonas, Euglena, Peridinium and the diatoms Synedra and Navicula were the first to recover following severe set-backs, whereas non-motile greens, blue-greens and other diatoms proved to be less resilient.

8. OTHER EFFECTS

Where willows, Salix spp. were growing near the edges of ponds treated with Simazine, chlorosis and eventual

browning of the tips of leaves resulted on the sides of the trees adjacent to the water. At one pond, two large willows were more seriously affected as all of the leaves eventually turned brown and extensive defoliation occurred. Small green shoots along the main trunks of these trees were observed late in the summer and observations will be necessary in 1966 to determine whether they will survive. Perhaps an unusually high total dissolved solids content of 748 ppm in this pond played some part in contributing to these severe effects. A smaller willow tree at one other pond was similarly affected.

9. ACKNOWLEDGMENTS

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10. REFERENCES

1. Blackburn, Robert D. 1963. Evaluating herbicides against aquatic weeds. Weeds 11 (1) : 21-24.

2. Johnson, Murray G. 1965. Control of aquatic plants in farm ponds in Ontario. Prog. Fish Culturist, 27 (1) : 23-30.

3. Lopinot, A. C. 1963. Aquatic weeds - their identification and methods of control. Fishery Bulletin No. 4, Division of Fisheries, Department of Conservation, State of Illinois, 47 pp.

4. Pierce, Phillip C., John E. Frey and Henry M. Yawn. 1964. Field evaluations of newer aquatic herbicides. Eighteenth Annual Conference, Southeastern Association of Game and Fish Commissioners. 20 pp. (Mimeo).

5. Riemer, Donald N. 1964. Observations on some acid water lakes treated with diquat. Proc. NEWCC, 18:489-495.

6. Ryder, R. A. 1964. Chemical characteristics of Ontario lakes, with reference to a method for estimating fish production. Section Report (Fisheries) No. 48. Ontario Department of Lands and Forests, 1964. 75 pp.

7. Snow, J. R. 1963. Simazine as an algicide for bass ponds. Prog. Fish Culturist, 25 (1) :34-36.

8. Walker, Charles R. 1964. Simazine and other s-triazine compounds as aquatic herbicides in fish habitats. Weeds 12 (2): 134-139.

9. Whitley, James R. 1965. Aquatic weed control in farm fish ponds. Proc. Aquatic Weed Control Society. 6 pp. (Mimeo).

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Experimental aquatic
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